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Abstract

Orthokeratology is the elimination, reduction, or change of myopic refractive error by programmed application of contact lenses. Accelerated ortho-k is a safe and effective alternative to refractive surgery, particularly for myopia of 3 D or less. We studied corneal thickness changes induced by applying ortho-k lenses over a period of eight weeks. Twelve subjects were evaluated using the pachometer, Orb Scan, and corneal topographer. Our evaluation of orthokeratology induced central corneal thickness changes, although showing no significant changes, will help in part to eventually achieve the ultimate goal of a systematic methodology for fitting orthokeratology lenses.

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EFFECTS OF ORTHOKERATOLOGY ON CENTRAL CORNEAL THICKNESS

By

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and
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Biography

Jeffrey Michael Goergen

I was Born on February 09, 1972 in Albert Lee, Minnesota. I was raised in Cedar Rapids, Iowa where I graduated from Linn-Mar High School. I received a Bachelor of Arts degree from the University of Iowa where I worked as a Resident Assistant for two years. I was married on July 1, 1995 to my college sweetheart, Melissa Worth. We spent our honeymoon in the Southern Carribean on a Carnival seven day cruise.

Upon graduation and licensure I plan to become an associate in a primary care setting somewhere in Iowa. Eventually I hope to buy into a private practice.

B. Scott Karaim

I was born in Kenora, Ontario, Canada. I lived most of my life in Edmonton, Alberta where I attended Jasper Place Composite High School . I went on to post-secondary school at the University of Alberta where I graduated with a Bachelor of Science in Physical Sciences. I played basketball for the University of Alberta Golden Bears from 1989-1994. In the spring of 1994 I married my high school sweetheart, Patricia Cooney. My optometric career started in the fall of 1994 where I began my studies at Pacific University College of Optometry in Forest Grove, Oregon. I am presently finishing my last semester in Calgary, Alberta and plan to practice in Edmonton, Alberta in the summer of 1998.

Abstract

Orthokeratology is the elimination, reduction, or change of myopic refractive error by programmed application of contact lenses. Accelerated ortho-k is a safe and effective alternative to refractive surgery, particularly for myopia of 3 D or less. We studied corneal thickness changes induced by applying ortho-k lenses over a period of eight weeks. Twelve subjects were evaluated using the pachometer, Orb Scan, and corneal topographer. Our evaluation of orthokeratology induced central corneal thickness changes, although showing no significant changes, will help in part to eventually achieve the ultimate goal of a systematic methodology for fitting orthokeratology lenses.

Key Words

Pachometry
Orb Scan
Accelerated orthokeratology
Reverse-geometry
t-test
Methodology

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Introduction

Orthokeratology is the elimination, reduction or change of myopic refractive error by programmed application of contact lenses. Approved ortho-k lenses accomplish this by remolding the anterior corneal curvature, making it flatter centrally, thus reducing or eliminating myopia and astigmatism. The lenses used are designed with flat central base curves which allow mechanical and hydraulic mechanisms to reshape the cornea. In the past several years this procedure has grown in popularity as an alternative to surgical corrective procedures. Numerous investigators have reported induced corneal curvature and refractive changes in contact lens patients (Kerns 1976). Practitioners have also reported improved unaided acuity's in contact lens patients after the removal of their lenses (Kerns 1976). This phenomena has been reported to continue for days, even weeks. The question is not whether changes following contact lens wear actually occur, but rather can changes be controlled in a predictable fashion? Our evaluation of orthokeratology induced central corneal thickness changes will help in part to eventually achieve the ultimate goal of a systematic methodology to fitting orthokeratology lenses in a predictable and controlled fashion.

Potential Applications

When orthokeratology becomes more clearly understood to the point that it is predictable and controlled, thousands of myopic patients will have a viable option to current refractive surgery techniques. Orthokeratology offers a unique, reversible alternative to refractive surgery at an affordable price. Orthokeratology is reversible in the fact that if the cornea is not changing shape properly the patient can discontinue lens wear temporarily which allows the cornea to "bounce back" to its original shape. A new pair of orthokeratology lenses can then be customized to achieve the desired outcome. The fact that ortho-k is reversible, offers reassurance to patients that may have shied away from the potentially devastating, irreversible consequences that may follow all current laser refractive procedures.

Large segments of the population can benefit from orthokeratology. For example, patients who enjoy water sports can, upon entering the water, achieve "functional" acuity without lens wear. There are also occupations, such as police and fire personnel, that require potential employees to have exceptional unaided visual acuity's. Orthokeratology is a viable option for such patients who wish to pursue careers that require minimal occupational vision standards, yet want to avoid the potential risks of laser corrective procedures.

There are also advantages for patients that have refractive errors that are too large to be completely corrected with orthokeratology lenses. For example, moderate to high myopes can be partially corrected from legally blind unaided visual acuities to unaided acuities that allow for maneuvering around the house in the middle of the night or other emergency situations. Finally, parents who wish to reduce the amount of myopia their children develop may be interested in ortho-k.

Purpose of the study

The main objective of the study was to precisely measure, in a clinical setting, how the central corneal thickness changes with the application of ortho-k lenses. More specifically, our goal was to answer the question, "Is there a significant change in central thickness when measured pre- versus post-orthokeratology application?" This is only one of many questions that must be answered before a systematic methodology for fitting ortho-k lenses can be developed. Other parameters such as peripheral corneal changes, intraocular pressure variations, and topographical fluctuations, must also be studied before an organized systematic methodology to fitting orthokeratology lenses can be developed.

Methods

The study involved the evaluation of 12 subjects (24 eyes) over the course of an eight week orthokeratology program. All of the subjects were required to have low to moderate myopic corrections (Approximately -1.0 to -4.0 diopters) with little or no astigmatism. The best candidates are myopes of less than 6.00 diopters with less than 3.00 diopters of astigmatism (Stoyan 1992). There was no exclusion based on the subjects history of previous contact lens wear. However, subjects with compromised ocular health based on ocular and systemic health histories, anterior segment evaluation, tonometry, and topographical mapping, were excluded. During the initial visit there were 20 prospective students from which we chose our target number of 12 subjects. There were 6 males and 6 females in the study, although no specific gender proportions were targeted. All of the subjects were from a target population of optometry students, one of which was a first year student the remainder being second year students. The subject's ages ranged from 20-years-old to 28-years-old. The subjects not chosen were excluded based on having larger than "ideal" myopic refractive errors and/or had demonstrated poor motivation.

Prior to ortho-k fitting there was an evaluation of the subject's current visual status which included an extensive case history and the following measurements:

1.) Visual acuities (with and without habitual correction)
2.) Refractive error
3.) Corneal thickness using the Topcon model-1 pachometer slit lamp attachment. Fluorescein was instilled on the conjunctiva prior to the evaluation of corneal thickness. The use of fluorescein allows for the examiner to distinguish the cornea from the tear layer, resulting in more precise pachometry measurements (Crook 1979).
4.) Anterior corneal curvature with Humphrey's computerized corneal topographer
5.) Posterior corneal curvature and anterior chamber depth with the Orb Scan model #1000
6.) Intraocular pressure using the Haag Streit slitlamp with the Goldmann tonometer
7.) Anterior eye health using the slit lamp
8.) Keratometric readings using the Bausch and Lomb Keratometer

Following the evaluation the subjects were fit with "accelerated orthokeratology" lenses, under the guidance of Dr. Neal Hodur. Most of the subject's initial lenses were fit 0.5 diopters flatter than their flattest base curves based on central keratometric readings. The specific lenses used were an OK-3 reverse-geometry design from the OK series of ortho-k lenses, available only from Contex. The OK series of lenses are made of fluoro-silicone acrylate material (Dk=88). The OK lens design is available as OK-2, OK-3, OK-4, OK-5P, OK-6 and OK-7. The numbers following the OK prefix denote how many diopters steeper the intermediate zone is than the optical zone. This steeper intermediate zone creates a channel that acts as a tear reservoir. The tear reservoir encourages sphericalization of the cornea and keeps the lens centered (Stoyan 1990). The peripheral curves are aspheric with their design based on the secondary rather than the base curve.

It is important that before dispensing the lenses a well centered lens and acceptable fluorescein pattern is achieved. An ideal fluorescein pattern exhibits moderate (2-3 mm) apical touch, a peripheral tear reservoir and 1-2 mm of movement with a centered lens (Figure 1.1 below). Once an ideal "bullseye" fluorescein pattern was achieved, the subjects were given their appropriate initial full-time daily wear ortho-k lenses.

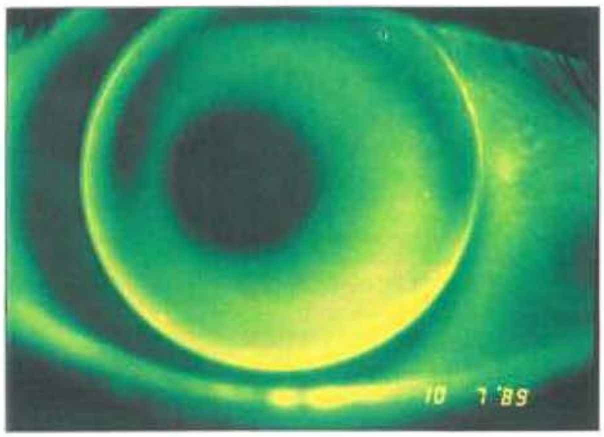

Figure 1.1 "Ideal lens fit" (Nataloni 1995)

The subjects were followed on a predetermined schedule after their initial fitting which included: follow-up at day 1, 3, 7, 14, 21, 28, 35, 42, 49 and 56. During each follow-up exam the following measurements were obtained (in the order specified below):

1.) Aided visual acuities distance and near
2.) Evaluation of lens fit using fluorescein patterns viewed under the slit lamp
3.) Unaided visual acuities distance and near
4.) Corneal thickness measurements using a Topcon pachometer
5.) Corneal topographical measurements
6.) Orb Scan measurements

Results

The subjects were followed for a period of eight weeks with measurements taken at day 1, 3, then weekly following orthokeratology fitting. The initial measurements for ortho-k fitting were taken on 12 subjects (24 eyes). The central corneal thickness changes were analyzed using repeated measures t-test statistics (Cravetter 1992). The most significant changes in acuities following ortho-k application were seen after two weeks of lens wear. At this point there were no significant changes in central corneal thickness ($t= -0.359$)(Table 1.1). As the study progressed there were fewer subjects due to drop-outs and noncompliance. By the fourth week there were 11 subjects (22 eyes) remaining in the study. At this point there was still no significant change in central corneal thickness as measured by pachometry ($t= 0.693$). During the eighth and final week of measurements there were only 4 subjects (8 eyes) remaining in the program, due to noncompliance and several patients losing their lenses. The final pachometry readings (week eight) showed that there were again no significant changes in central corneal thickness ($t= 0.979$). We concluded that in our particular study the central corneal thickness remains statistically unaffected when manipulated with the OK-3 series of orthokeratology lenses.

Discussion

Accelerated orthokeratology is a safe and effective alternative to refractive surgery, particularly for myopia of 3D or less. In ortho-k the cornea is manipulated similarly to that seen in incisional and ablative surgical procedures, without the invasion of corneal integrity. The cornea is remolded into a shape that is flatter centrally and steeper in the mid-periphery. Orthokeratology fitting philosophies and lens materials have varied over the years with reverse-geometry lenses currently being the lens of choice, allowing for an accelerated effect with increased control. The OK-3 reverse-geometry lenses that were used in our study appear to reduce myopia by twice the amount of previous methods, in about half the time (Horner 1994). Although no significant central corneal thickness changes were found in our study, other studies need to be conducted to help explain how corneal tissue is displaced with the application of orthokeratology lenses. Other parameters such as; peripheral corneal changes, intraocular pressure variations, and topographical fluctuations, must be analyzed before an organized systematic methodology to fitting orthokeratology lenses can be developed.

TABLE 1.1

1	0.390	0.450	0.060	0.004	0.390	0.000	0	0.395	0.005	0.000
2	0.382	0.450	0.068	0.005	0.455	0.073	0.005			
3	0.522	0.475	0.047	0.002	0.495	-0.027	0.001			
4	0.420	0.455	0.035	0.001	0.460	0.040	0.002	0.435	0.015	0.000
5	0.460	0.425	-0.035	0.001	0.400	-0.060	0.004			
6	0.490	0.425	-0.065	0.004	0.000	0.000	0.000			
7	0.420	0.425	0.005	0.000	0.400	-0.020	0.00	0.470	0.050	0.003
8	0.440	0.455	0.015	0.000	0.490	0.005	0.003			
9	0.410	0.425	0.015	0.000	0.450	0.040	0.002	0.460	0.050	0.003
10	0.480	0.505	0.025	0.001	0.500	0.020	0.000			
11	0.448	0.440	-0.008	0.000	0.430	-0.018	0.000			
12	0.495	0.485	-0.010	0.000	0.480	-0.015	0.000	0.500	0.005	0.000
13	0.476	0.460	-0.016	0.000	0.435	-0.041	0.002	0.440	-0.036	0.001
14	0.462	0.450	-0.012	0.000	0.445	-0.017	0.000			
15	0.500	0.460	-0.040	0.002	0.490	-0.010	0.000			
16	0.470	0.445	-0.025	0.001	0.460	-0.010	0.000	0.430	-0.040	0.002
17	0.442	0.425	-0.017	0.000	0.460	0.018	0.000			
18	0.475	0.435	-0.040	0.002	0.000	0.000	0.000			
19	0.400	0.405	0.005	0.000	0.420	0.020	0.000			
20	0.485	0.475	-0.010	0.000	0.500	0.015	0.000			
21	0.420	0.410	-0.010	0.000	0.425	0.005	0.000	0.460	0.040	0.002
22	0.510	0.490	-0.020	0.000	0.515	0.005	0.000			
23	0.430	0.405	-0.025	0.001	0.455	0.025	0.001			
24	0.480	0.480	0.00	0.000	0.490	0.010	0.000	0.495	0.015	0.000
		Sums	-0.058	0.024	Sums	0.103	0.021	Sums	0.104	0.010
		Mean of Difference	-0.002		Mean of Difference	0.005		Mean of Difference	0.013	
		Sum of Squares		0.024	Sum of Squares		0.020	Sum of Squares		0.009
		Standard Devuation	0.032		Standard Devuation	0.031		Standard Devuation	0.035	
		Estimated Std. Error	0.007		Estimated Std. Error	0.007		Estimated Std. Error	0.013	
		t-value	-0.359		t-value	0.693		t-value	0.979	

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